

## THE MID-ATLANTIC INTEGRATED ASSESSMENT (MAIA)

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### 1. Background

Since its inception, EPA has focused its research and monitoring towards its regulatory requirements – to protect air and water quality, to control the use of pesticides and toxic substances, to ensure the safe production, handling, and disposal of industrial chemicals, and to clean up abandoned hazardous waste sites. Monitoring programs were instituted by federal, state, and local governments to ensure that regulations were being properly enforced. These monitoring programs responded to programmatic requirements and were not integrated in any formal manner. While these programs could demonstrate that individual problems were being effectively dealt with, they could not provide a comprehensive picture of the condition of our nation's natural resources.

Calls for improvements in monitoring date back to the late 1970s. A long series of internal and external reports have recommended the need for significant advances in the way EPA and other federal agencies monitor the condition of our environment. Even EPA's Administrators have been surprised that our environmental monitoring programs were not able to answer very basic questions, e.g., William Ruckelshaus was shocked to find out that EPA did not know how many acid lakes there were and William Reilly stated in a 1989 speech that based on his years in the environmental movement, he thought the Agency did an exemplary job of protecting the nation's public health and quality of the environment, but that he couldn't prove it.

The U.S. EPA Science Advisory Board's (SAB) report *Future Risk: Research Strategies for the 1990s* (USEPA 1988) was the stimulus for many of the changes in EPA research and monitoring efforts. The SAB recommended that EPA undertake research on techniques that could be used to help anticipate environmental problems, and make a more concerted effort to be aware of, and interact with, the research efforts of other Federal agencies concerned with the anticipation of environmental problems. To support these goals, EPA was urged to place more emphasis on evaluating environmental trends and assessing other predictors of potential environmental problems before they become acute.

Responding to the SAB's recommendations, EPA initiated the Environmental Monitoring and Assessment Program (EMAP) to: "Monitor the condition of the

Nation's ecological resources to evaluate the cumulative success of current policies and programs and to identify emerging problems before they become widespread or irreversible" (Messer et al. 1991).

EMAP was "a new way of doing business." It addressed the larger scale, longer term environmental problems occurring at regional and national scales. Instead of taking the traditional single-chemical or single-site approach to environmental assessment, EMAP adopted a comprehensive, multimedia approach to answering questions about overall ecological condition and the health of the environment.

EMAP adopted a tiered approach to monitoring. The foundation of this approach was a national land cover characterization using satellite based remote sensing (Mace 1990). The second level incorporated probability-based field sampling surveys to obtain national and regional estimates of status and trends for important indicators of condition and exposure (Stehman and Overton 1991). Finally, a network of intensive research and monitoring sites provided information about ecological processes and their interactions relevant to the observations from the other tiers (Summers and Tonnessen 1998).

The early years of EMAP focused only on developing and demonstrating the remote sensing and survey tiers. Operating under common approaches to indicators and design, individual components of the program (arid lands, agroecosystems, estuaries, forests, Great Lakes, surface waters, and wetlands) began to develop and evaluate the approaches in different portions of the country. However, in spite of significant interagency collaboration in many of the components, national demonstration or implementation was not achieved for any of the resource areas.

In spite of the failure to implement the "National EMAP", the continued calls for more efficient use of the large amount of resources going into environmental monitoring continued in the 1990s and re-emphasized the need to continue the development of the EMAP concept. In 1995, Vice President Gore stated "Environmental monitoring is the foundation for the scientific information necessary to make wise decisions key to meeting the twin goals of continued vigorous economic growth and preservation of our environmental heritage...the health of our ecosystems is integral to the health of our people" and called for improvements in environmental monitoring (National Science and Technology Council 1997).

In 1994, under the direction of the White House, the National Science and Technology Council's Committee on the Environmental and Natural Resources (CENR) reviewed and evaluated the nation's environmental monitoring. Dr. Jerry Melillo, summarized the results of that study in a speech given during the National Environmental Monitoring and Research Workshop (September 25-27, 1996 Smithsonian Institution, Washington, DC). The CENR concluded that after 26 years, federal, state and local agencies still collect a variety of data that are fragmentary and incompatible in type and coverage on a national scale. However, they went on to state that we have made advances with the development of new monitoring tools, i.e., remote sensing, sophisticated instrumentation for in situ data collection, geographic information systems (GIS), and simulation techniques to aid

in analysis and synthesis of data. They recommended that federal agencies strive to coordinate monitoring and research efforts to develop better national assessments and placed particular emphasis on assessment tools that would reflect conditions across ecosystems, and at various spatial scales (Committee on the Environment and Natural Resources 1996).

Based on critical reviews of the EMAP effort by CENR and others, the decision was made to focus the effort to a regional scale and develop a model which could be transferred to other areas of the country. The mid-Atlantic was selected because of the data richness and strong interest of the EPA Regional Office and mid-Atlantic states. EPA Region 3 formed a joint venture with the EPA Office of Research and Development—known as the Mid-Atlantic Integrated Assessment (MAIA)—a research, monitoring and assessment initiative to develop high-quality scientific information on the condition and stressors of natural resources within the mid-Atlantic region of the United States.

Building on the MAIA effort, the CENR also selected the mid-Atlantic region to lead White House efforts in integrating federal environmental research and monitoring activities. Under the auspices of the CENR, the Mid-Atlantic Inventory was developed to facilitate the assessment of existing monitoring programs (Jackson and Gant 1998). The inventory presents 128 federal research and monitoring programs that operate in the mid-Atlantic region and is organized by sampling design into three tiers recognized by the National Environmental Monitoring Initiative (National Science and Technology Council 1997).

## **2. The MAIA**

The mid-Atlantic region is an area of historical, cultural, economic, ecological significance. The mid-Atlantic region encompasses over 120,000 square miles and extends from the Atlantic Ocean to the Ohio River, and from New York to North Carolina, including all of Delaware, Maryland, Pennsylvania, Virginia, West Virginia, and the District of Columbia and portions of New Jersey, New York, and North Carolina. The mid-Atlantic region contains a mosaic of ecological systems - lakes, streams, forests, agricultural areas, wetlands, and estuaries.

The mid-Atlantic region is home to over 35 million people (BOC 1998) and has experienced some of the most rapid growth of population, industrial development and intensive agriculture in the country. This growing population has had a concurrent rapid growth in demand for land for homes, transportation, commerce, jobs, and recreation. Urban land currently comprises 5% of the region's watershed and dominates much of the estuarine shoreline. As watersheds are becoming more developed, the amount of impervious surface area increases, the amount of pollutants carried in the storm-water increases, and the amount of wastewater and solid waste requiring disposal all increases, placing additional pressure on the living resources and valued ecosystems.

The mid-Atlantic has a wide range of environmental problems associated with human activities including air quality issues (ambient ozone, acid rain), water quality problems (eutrophication, acid mine drainage), solid waste disposal problems (contaminant leachate), large-scale habitat alteration from urbanization, agricultural and forestry management practices, hydrologic modification, and loss of biotic diversity. These problems are not unique to the mid-Atlantic and thus solutions to environmental problems in the mid-Atlantic region should be transferable to other geographic areas.

The goal of the MAIA is to focus research efforts on assessment issues that are of critical importance to resource managers and environmental decision-makers. The MAIA Team, located at Ft. Meade, MD, was created as a joint venture between the EPA Office of Research and Development and EPA Region 3 to create partnerships with other Federal, State, and local agencies in the conduct of ecological research, monitoring, and assessments. The Team has successfully accomplished this goal, developing collaborative efforts through formal and informal arrangements with most of the Federal and State agencies, many NGOs, academia, and private sector components with responsibilities for environmental issues in the mid-Atlantic area. Through these multiple stakeholder efforts, the MAIA Program has successfully completed several assessments of the condition of individual resources in the mid-Atlantic region.

### **3. The Landscape Atlas**

The Landscape Atlas was the first regional-scale ecological assessment completed in the MAIA (USEPA 1997a). The report is based on data from satellite imagery and spatial databases on biophysical features such as soils, elevation, and human population patterns. It compares nine landscape indicators on a watershed-by-watershed basis for the lower 48 states (at a relatively coarse-scale resolution of 1 km), placing the mid-Atlantic region in the context of the rest of the country. Using finer-scale spatial resolution (e.g., 30–90 meters), the report then analyzes and interprets environmental conditions of the 125 watersheds in the mid-Atlantic region based on 33 landscape indicators. Results are presented relative to four general themes identified by stakeholders in the region: 1) people (potential human impacts), 2) water resources, 3) forests (forest habitat), and 4) landscape change.

The Atlas compares watersheds using color codings based on the authors' interpretation of "more" vs. "less" desirable ecological conditions. For instance, a high degree of forest cover is rated as more desirable than limited forest cover. The watersheds are ranked relative to each other, not on an absolute scale of ecological desirability. All indicator values are presented for each watershed in an Appendix, so readers can draw their own conclusions.

It identifies, with never-before achieved detail and comparability, patterns of land cover and land use across the region, presenting an ecological snapshot that enables one to visualize the environmental conditions across the region, and how the pattern of conditions can be applied to environmental decision making.

#### **4. Estuaries—The Report and the Regional Monitoring Initiative**

*The Condition of the Mid-Atlantic Estuaries* was the second region-wide assessment completed in the MAIA (USEPA 1998a). This report presents a synthesis of information published in a variety of scientific reports and databases, focuses on the condition of the mid-Atlantic estuaries from the early- to mid-1990s, and how and why the estuaries have changed over the years. The mid-Atlantic estuaries included in this report are: the Delaware Estuary, the Chesapeake Bay, and the Delmarva coastal bays. Numerous research studies have been prepared by federal and state programs and by academic researchers for individual states or watersheds; however, a comprehensive report covering water quality, sediment contamination, habitat change, and the condition of living resources had never been done on a regional scale. Data from across all Federal and state programs have been used and comparisons of one estuary to another within the region have been made. The report identifies specific geographic problem areas, and provides estimates of the percentage of estuaries that are in good, moderate, or degraded condition based on various environmental parameters.

The report illustrates that while the estuaries in the mid-Atlantic region are being adversely affected by human activities, the states, in conjunction with EPA through the Chesapeake Bay Program and the National Estuary Programs, have instituted successful environmental management programs to address these environmental challenges. This work must be continued and expanded if the goals established for the future are to be met.

In 1997, based upon the Estuaries report, the MAIA stakeholders/partners began a coordinated monitoring effort of the mid-Atlantic estuaries to address the data gaps identified during the development of the "Condition of the Mid-Atlantic Estuaries Report". The MAIA Estuaries Team was established to approach integration through the assessment process, rather than by comparing monitoring designs. Using the report as a starting point, they identified the appropriate assessment questions to characterize the condition of the estuaries and identify questions which could not be answered because validated indicators were lacking. A set of core indicators and consistent protocols were selected which would address issues relevant to toxic contamination in the food chain, water, and sediment.

The Estuaries Team developed a comprehensive integrated monitoring design which consisted of more than 700 stations throughout the mid-Atlantic estuaries, including stations selected through both the probabilistic and deterministic approaches. Field activities during the summer of 1998 focused on fish, and addi-

tional field activities were performed in 1999 in two small estuaries, to provide additional data on the variability of small estuarine systems. The ultimate goal of this cooperative research program is to design an efficient, cost effective integrated monitoring approach for the mid-Atlantic which will evolve into a long term, continuous monitoring effort.

## 5. Surface Waters

The *Condition of the Mid-Atlantic Streams Report* will be modeled after the *Condition of the Mid-Atlantic Estuaries Report*. A Streams Assessment Group has been formed and has begun to develop assessment questions and identify sources of data. However, there are several technical issues which are still being addressed: combining data sets from different monitoring programs, indicator development and calibration, index development, and integration of probability and non-probability deterministic samples.

The *Condition of the Mid-Atlantic Streams Report* will integrate the results of a variety of ongoing efforts. The data from the stream sampling component of EMAP will be analyzed and summarized in the more geographically focused *Mid-Atlantic Highland State of the Streams Report* (in preparation). This report will provide an overview of the condition of streams throughout the Mid-Atlantic Highland area, and discuss potential stressors to these stream ecosystems and potential management options to reduce these effects. This project was unique for two reasons: it applied a probabilistic monitoring design at a regional scale; and it developed and implemented biological indicators in addition to the traditional chemical indicators of water quality. Two support documents are also under development, i.e., the *Technical Support Document* which will serve as technical documentation and explanation of the basis of the information contained in the *Mid-Atlantic Highlands State of the Streams* report, and the *Feasibility Report*, which will review and validate the biological indicator results of the EMAP effort and address critical issues for implementing biological criteria in Region 3 states. These efforts will serve as a pilot for the EPA Office of Water's biocriteria program and a potential model for other areas of the country.

The MAIA has also supported the development of *From the Mountains to the Streams - An Environmental Report on Maryland's Freshwater Streams*, by the Maryland Department of Natural Resources, utilizing the EMAP probabilistic design and biological indicators at a state level. When combined with the *Mid-Atlantic Highlands State of the Streams* data into the *Condition of the Mid-Atlantic Streams Report*, this component of the MAIA effort will demonstrate how monitoring programs can address environmental issues at different scales.

The USGS produced another report which will contribute to the *Condition of the Mid-Atlantic Streams Report* – the report *Pesticides in Surface Water of the Mid-Atlantic Region* (USGS 1997a). This report, (based on non-probability based

data from USGS monitoring programs) describes the occurrence and distribution of pesticides in surface water in the mid-Atlantic region. The occurrence of selected pesticides in surface water is compared to established Federal standards - the Federal Maximum Contaminant Level (MCLs) for drinking water and aquatic health and linked to possible explanatory factors such as seasonality and streamflow. Major spatial gaps in surface-water pesticide data collected by the USGS are identified, and limitations of currently available data for analyses of this type are discussed.

As part of the MAIA, support has also been provided for the Mid-Atlantic Coastal Streams (MACS) Workgroup, which developed standard methods for the collection and processing of biological and physical habitat data in low gradient nontidal streams of the Mid-Atlantic Coastal Plain ecoregion. Products resulting from this work include: *Field and Laboratory Methods for Macroinvertebrate and Habitat Assessment of Low Gradient, Nontidal Streams* (USEPA 1997b), the *Data Report: Assessment Framework for Mid-Atlantic Coastal Plain Streams Using Benthic Macroinvertebrates* (USEPA, in press), and a fact sheet about the project.

The methods developed as part of the MACS effort were integrated with those developed for the Highlands into the MAIA streams monitoring program. In 1997 and 1998, MAIA conducted MAIA-wide monitoring using a suite of indicators to estimate the biological integrity of biologic communities in streams and river, and to evaluate the relative magnitudes of stressors. The monitoring will also be used to: 1) demonstrate how concepts of biocriteria, ecoregions, watersheds, and probability surveys can be used in concert to address environmental issues within the region, 2) show that multiple agencies and institutions at the state and federal levels can work collaboratively to address common monitoring and assessment needs, and, 3) provide baseline information required to conduct comparative ecological risk assessments for streams/ivers in the mid-Atlantic.

## 6. Forests

The USDA Forest Service, a MAIA partner, is leading the effort to produce a *Condition of the Mid-Atlantic Forests Report*, which will address the major themes of forest health, ecological sustainability, and ecological and socio-economic/cultural interactions. This effort aligns with the National commitment to sustainable forest management and conservation principles identified in the Santiago Declaration of 1996 (Anon 1995). The report will cover major forest stressors, i.e., abiotic (air pollution, storms, fires), biotic (insects, disease, exotics); land use and management practices; forest response and condition, ecosystem diversity, biological diversity, tree vitality, conservation of aquatic and soil systems, productivity, and carbon cycling; and urban forestry.

The Forest Health Monitoring (FHM) program is the lead Forest Service component for this effort. FHM is a multi-agency, cooperative effort to assess the sta-

tus, changes, and trends in forested ecosystems of the U.S. (Forest Health Monitoring 1994). The goal of FHM is to assist USDA in managing the national forest resources in a sustainable manner, ensuring that current and future generations will be able to utilize all the beneficial attributes of the forests.

The development of this report was initiated with a stakeholders workshop in 1997 where assessment questions, based on the tenets of the Santiago agreement, were presented to the group for review and modification. A key result of the workshop was the identification of three additional focus areas: landscape ecology, wildlife, and aquatic systems, that required a more detailed analysis than originally planned. The Forest Health Monitoring team organized three expert teams to address the data gaps that were identified.

The effort will culminate in a series of discussions to refine the document, a final stakeholders meeting, and publication of the report.

## 7. Agriculture

As part of EMAP, a collaborative effort was developed with the USDA Agricultural Research Service (ARS) to explore methods for assessing the health of agroecosystems. The first products of this effort were a series of peer-reviewed journal articles (Hellkamp et al. 1998, Olson et al. 1996, McQuaid 1996, Neher et al. 1998) and a public-use database (in preparation). These efforts will serve as the basis for the *Condition of the Mid-Atlantic Agricultural Lands Report*.

The next step in the development of the *Condition of the Mid-Atlantic Agricultural Lands Report* was a joint effort with the Maryland Department of Agriculture, the *Characteristics of Maryland Agriculture Relevant for Environmental Assessment* (in preparation). This report was developed to demonstrate the utility of the EMAP approach, and to explore additional ecology-based analyses using existing available data.

The MAIA is developing the assessment process for Agricultural lands, bringing together environmental managers (federal, state and local) and scientists to develop relevant assessment questions, identify appropriate indicators, and select data sources. The report is planned for publication in 2002.

## 8. Wetlands

Wetlands are perhaps the most difficult resource to characterize of all the ecological resources occurring in the mid-Atlantic. The *Army Corps of Engineers Wetlands Delineation Manual* (US ACOE 1987) defines wetlands by the predominance of hydrophytes (plants adapted for life in wet soils), and the presence of hydric soils (saturated or periodically flooded soils). While it is relatively simple to delineate tidal wetlands using remote sensing techniques, it is difficult to



delineate wetlands in forested areas, limiting our capability for a comprehensive assessment of the location, areal extent and condition of wetlands in the mid-Atlantic.

The MAIA is supporting two pilot studies assessing the ecological condition of wetlands in the Juniata River (PA) and Nanticoke River (DE/MD) watersheds of the Chesapeake Bay drainage area. The studies are: 1) based on the EMAP sampling design, 2) provide a quantitative description of the condition of the resource, and 3) employ appropriate bioindicators. Methods are being developed in 1999, and sampling will occur during the 2000 field season.

The results of these studies will assist in identifying and validating the best indicators of wetland condition in the mid-Atlantic, provide the foundations for larger scale studies, and ultimately lead to a report on the condition of the mid-Atlantic wetlands.

## 9. Ground Water

Groundwater was not one of the seven key resources selected for assessment in the original EMAP design, but due to its importance to the vitality and sustainability of the mid-Atlantic, it has been added to the MAIA and several focused assessments have been completed.

The U.S. Geological Survey (USGS) currently maintains a large data base on groundwater quality in the mid-Atlantic region. Most of these data were collected as part of the National Water-Quality Assessment (NAWQA) program or of monitoring programs conducted by the USGS in cooperation with other local, state, and federal agencies. As part of the USGS participation in the MAIA, a report on *Nitrate and Selected Pesticides in Groundwater in the Mid-Atlantic Region* was developed (USGS 1997b). Nitrate was selected for discussion because it is the most common contaminant in ground water (Freeze and Cherry 1979). The occurrence of nitrate and selected pesticides in ground water is compared to established Federal standards for drinking water, the Federal Maximum Contaminant Level (MCL), and to possible explanatory variables such as land cover and rock type.

An additional hydrogeologic assessment in the mid-Atlantic coastal plain is also being planned under a project entitled "Collaborative Assessment of Landscapes and Water Quality in the Mid-Atlantic Coastal Plain". The goal of this effort is to develop land cover composition and pattern indicators, e.g. patch sizes, miles of buffer zone per mile of stream, and mean distance of road to stream, which will enable an assessment of the vulnerability of freshwater streams and groundwater to pesticides, nutrients, and toxic substances.

Exploratory discussions are currently underway to see if these focused efforts could culminate in a report on the condition of the mid-Atlantic ground water.

## 10. The Future of the MAIA

As previously described, in the near future, the MAIA effort will soon have completed "Condition" reports on estuaries, land use, forests, and surface waters. In addition, focused efforts are coming to completion which will be the foundation for similar reports on agroecosystems, groundwater, and possibly wetlands and biodiversity. With this basis, the MAIA effort is moving on to the next steps which will involve better characterization of stressors on these resources, prediction of future condition of the resources if these stressors are not mitigated, developing control strategies for managing the major stressors, and initiating projects associated with restoring damaged ecosystems. Thus, the next steps involve the development of methods for integrated assessments which will explore the interactions and impacts of changes in condition across resources and the development of indicators which cross resource categories.

The Regional Vulnerability Assessment (ReVA), which will initially focus in the mid-Atlantic region, will be a major component to this effort. ReVA will develop the next generation of measurements, models, and tools necessary to assess the vulnerability of ecosystems to stressors imposed by the simultaneous impacts of wide-spread population growth, urbanization, industrial pollution, nonpoint source agricultural pollution, and climate change. The first phase of this effort was the *Mid-Atlantic Stressor Atlas* (USEPA in prep b) which delineates the major stressors in this region: mining, agrochemicals, ground level ozone, and land use change. The next steps will look beyond the "snapshots" in the Atlas, using predictive models to explore how trends in land use and economics drive these stressors. Special emphasis will be placed on examining socioeconomic forecasting models that can help explain and predict the impacts of changes in resource condition on regional economies and culture and the effects of social and economic changes on resources.

The major products that are planned as part of the next phase of the MAIA will be three integrated assessment reports: a synthesis of information across all MAIA resources for current status, an integrated assessment on a specific theme (e.g., eutrophication) and geographic place (e.g., the Mid-Atlantic Highlands and the Potomac/Northern Chesapeake Bay), and an integrated assessment crossing the major MAIA resources and themes. The MAIA defines Integrated Assessment as an assessment that brings together data about ecological and human effects, social goals, economics, politics, and law into the policy arena.

To support these integrated assessments, efforts will continue to explore the use of integrative indicators in long-term monitoring. Two of the most promising efforts involve expansion of the amphibian and avian community work. The amphibian projects discussed by Jung et al., in this proceedings will be continued and expanded to further test the value of amphibians as indicators. The development of a Region-wide amphibian calling survey, modeled after the Wisconsin program (Mossman et al. 1998) will also be initiated. The Bird Community Indicator and

breeding bird survey efforts discussed by O'Connell et al., Jones et al., and Cam et al. will be continued with the ultimate goal of developing a Region-wide avian monitoring effort. Both efforts will be supported under the Regional Environmental Monitoring and Assessment Program (USEPA 1993) to determine whether volunteer-based monitoring efforts can provide the foundation for cost-effective long-term monitoring of bioindicators which integrate across resource categories.

The next phase of the MAIA will also begin to explore the impacts of changes in resources on public health. This phase will be linked to collaborative efforts associated with global change (the Mid-Atlantic Regional Assessment of Global Change – MARA) and will likely focus on issues such as: changes in the dynamics of vector-borne diseases, e.g., lyme disease and viral encephalitides; illnesses related to nutrient imbalances in aquatic systems, e.g., neurocognitive abnormalities linked to Pfiesteria toxin, methemoglobinemia, and adverse pregnancy outcomes; and waterborne diseases such as cryptosporidia and other dysenteric illness.

The last component of the next phase of the MAIA will deal with risk management and be associated with control of stressors and restoration of damaged ecosystems. ORD's National Risk Management Laboratory has developed an ecorestoration research strategy (USEPA 1997), including several focused efforts in the MAIA involving the development of cost-effective and reliable approaches for restoring riparian zones; providing diagnostic tools and models for assessing feasibilities, priorities and measures of success for watershed restoration projects; issuing guidance on the application of the tools and models; and pilot restoration projects.

In its short existence, the MAIA has forged alliances with other federal and state agencies producing an array of products on estuaries, groundwater, streams, land use and landscape attributes, and other related topics. In the next century, the MAIA will continue to build on this foundation and create an arena in which innovative approaches for environmental assessment and management can be developed, validated, refined, implemented in a collaborative manner, and transferred to other EPA Regions, federal, state and local agencies and the MAIA partners. Information on the MAIA program can be obtained at <http://www.epa.gov/maia> on the Internet.

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